Preparing NASA Remote Sensing Data for Air Quality Models

Making NASA Remote Sensing Data Directly Usable in Multiscale Air Quality Models

NASA/Goddard EARTH SCIENCES DATA and INFORMATION SERVICES CENTER (GES DISC)
Steve Kempler[1], Daniel Tong[1,2]
[1]NASA/GSFC GES DISC, [2]George Mason University
Steven.J.Kempler@nasa.gov

Abstract

- Air quality modelers represent an important group of NASA Earth science data users. The process of locating, filtering and interpolating remote sensing data for use in air quality model development is, however, still a barrier to the broader use of satellite data by air quality modelers and model users. Incompatibilities between remote sensing data and model required data formats have also hindered remote sensing and model intercomparisons and validation.
- This presentation describes NASA data that are of interest to air quality modelers, challenges that air quality modelers face in using this data, and a potential solution that address these challenges. Implementation examples of spatial projection, quality filtering, data format conversion and data visualization are provided.

Problem

- Popular Air Quality Models, such as the Community Multiscale Air Quality (CMAQ) mode, and the NASA-Unified Weather Research and Forecasting (NU-WRF) model, require data inputs to be of specific formats and projections.
- NASA Earth science remote sensing data, in it's native form does not conform to these required formats and projections, causing much effort in converting data formats and reprojecting data, in geographical domains of specific interest.

Technical Challenges

- Having specialized data access services for Level 2 data: Regional modelers prefer high resolution satellite data, while most data services provide merged Level 3 products
- Obtaining quality filtered data: Data quality filtering requires in-depth understanding of the specific data product, and knowledge of common practices by the air quality and remote sensing communities
- Acquiring proper horizontal projections: Regional modelers define their own horizontal gridding with regular spacing in distance, not necessarily following latitude/longitude lines
- Acquiring data in formats that are model ready: Data needs to be converted into formats compatible with air quality models.

Addressing the Challenges - Requirements

Preparing NASA data for direct use in Air quality models

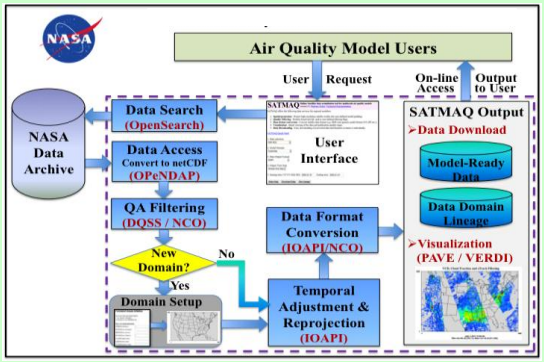
- **Spatial projection** - Cast high-resolution Level 2 satellite data directly into dynamically generated user-defined regional model gridding.
- **Format conversion** - Convert HDF or netCDF data into model specific formats.
- **Quality filtering** - Apply quality control flags to filter data.
- **Temporal resolution adjustment** – Adjust desired data to extract data coincident with model requirement.
- **Model ready output** – Provide modelers output files in specific format and projection directly usable in their model, consistent with other model inputs.
- **Domain Definition** – Allow modelers to dynamically define their own domain
- **Browse images**– Allow quick look at domain data results
- **Expandability** – Provide capabilities that can be reused/adapted for other models.

Preparing NASA Remote Sensing Data for Air Quality Research and Modeling
Proof of Concept

Implementation

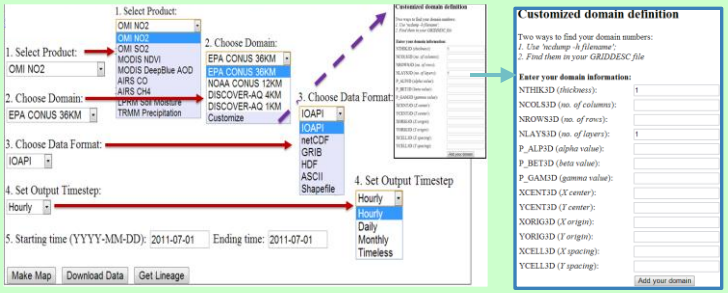
- Learning from previously developed interpreters: Wisconsin Horizontal Interpolation Program for Satellites (WHIPS) (Holloway, Univ. of Wisconsin)

Component	Technical Approaches	Usage
Search NASA data	OpenSearch Services (OSS)	Use OpenSearch implementation to download distributed data location search result
Access and convert data to netCDF	OpenDAP	Coupled with OpenSearch, use the popular OpenDAP protocol for common data conversion.
Perform data quality screening	DQSS (Data Quality Screening Service); Alternative: NCO (netCDF Operators)	Use operational quality screening code to provide users with highly desired quality assessment.
Horizontal reprojection	IOAPI (Input/Output Application Programming Interface)	Open Source IOAPI provides reprojection routines tailored for AQ modeling
Convert data to IOAPI file format	IOAPI or NCO	IOAPI routines convert data into the specific output format, required for CMAQ modelers; Reusing Open Source NCO may require less overhead
Visualize data	PAVE (Package for Analysis and Visualization of Environmental data) and VERDI (Visual Environment for Rich Data Interpretation)	Used by AQ modelers, both PAVE and VERDI are flexible and distributable applications to visualize, specifically, environmental data.

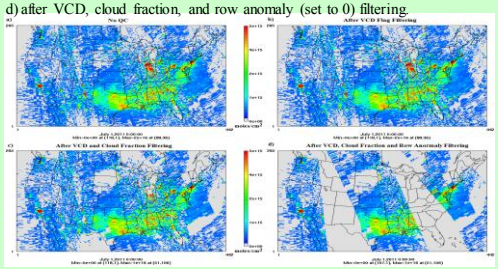


User interface to dynamically select data and domain

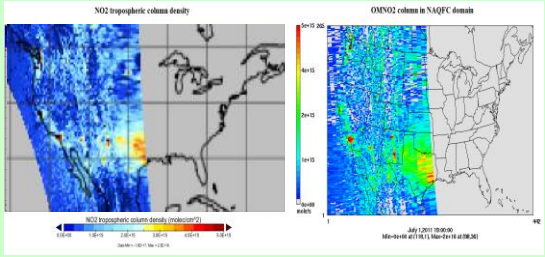
- Choose from pre-determined domains
- Create specific domain of interest



Sample Results: Comparison of daily OMI tropo. NO2 vertical column density (VCD) before and after quality control: a) no quality control; b) VCD quality flag set to zero; c) additional filtering with could fraction < 50%; and d) after VCD, cloud fraction, and row anomaly (set to 0) filtering.



Sample Results: Spatial projection of OMI NO2 Level 2 swath (left) into a Lambert Conformal CMAQ domain (12km x 12km over the continental United States) (right)



Interested Air Quality Projects

- Deriving Information on Surface Conditions from Column and Vertically-Resolved Observations Relevant to Air Quality (**DISCOVER-AQ**). (Dr. Ken Pickering, Project Scientist)
- **Air quality forecasting research**, lead by Dr. Pius Lee, NOAA Air Resources Laboratory (ARL).
- **Community Modeling and Analysis System (CMAS)** center for air quality modeling community, directed by Dr. Adel Hanna.
- University of Wisconsin (Tracy Holloway, also deputy leader of NASA's Air Quality Applied Science Team [AQAST]) projects **to analyze NO2 trends**, and evaluating lightning NOx in CMAQ.

Conclusions

- Satellite remote sensing data and services hold great promise to alleviate limitations of monitor-based environmental data collecting
- Obstacles such as uncertainties in methodology, data accessibility and data quality are being addressed
- Interpreting remote sensing data to address the specific needs of end user communities, such as air quality modelers and health impact studies, can be done, and should be further pursued to facilitate data usability by these communities